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Cooperating States
Departments of
Agriculture

Emergency Programs Manual

Action Plan

Spodoptera
(February 1991)

Department of Agriculture

Animal and Plant Health Inspection Service

Cooperating State Departments of Agriculture

GENUS SPODOPTERA--EXOTIC TO NORTH AMERICA

February 1991

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Comments

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AUTHORIZATION

This Action Plan provides guidelines and actions for the eradication of an infestation of exotic Spodoptera. This Action Plan supplements information contained in the Plant Protection and Quarantine (PPQ) Treatment, Emergency Programs, and Administrative Procedures Manual.

It is to be used in conjunction with other manuals when conducting emergency program activities. The information and instructions contained in this Action Plan were developed with and approved by representatives of the Animal and Plant Health Inspection Service (APHIS), cooperating States, Agricultural Research Service (ARS), Cooperative State Research Service (CSRS), and affected industry.

All program technology and methodology are determined through discussion, consultation, or agreement with the cooperating State officials.

James W. Glosser — 11/21/90

Administrator
Animal and Plant Health Inspection Service

Date

Gary W Carr — 12/5/90

Chairman
National Plant Board

Date

NOTICE

Pesticides recommended in this Action Plan are registered or may be exempted under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), as amended. Precautions on the pesticide label and all instructions in this Action Plan must be carefully followed.

Federal and State personnel may not make any warranty or representation, expressed or implied, concerning the use of these products and shall not be responsible for any loss, damage, or injury sustained as a result of the use of any product as specified in this Action Plan.

The use of trade names in this Action Plan does not imply an endorsement of those products or of the manufacturers thereof by Federal-State pest control programs. Equivalent formulations under different trade names are acceptable.

I. GENERAL INFORMATION

A. Action Statement

The information contained in this document is intended for use when an infestation of an exotic Spodoptera moth is known to exist. This Action Plan is for guidance in implementing eradication procedures and in preventing spread to other locations. It provides technical and general information needed for any phase of a Spodoptera eradication program. Specific emergency program action is to be based on information available at that time.

B. Background Information

The genus Spodoptera (Noctuidae) contains some of the most economically important insect pests of cultivated crops. Several important species are not known to be established in North America. The most important of these are Spodoptera exempta, S. littoralis, S. litura, and S. mauritia. In addition, S. cilium, S. marima, S. ochrea, S. pecten, and S. triturata, which are considered minor pests in their own endemic areas, are also not known to occur in North America.

S. littoralis, the Egyptian cottonworm (ECW), is known from Africa, Southern Europe, and the Near East. S. litura, the rice cutworm (RCW), occurs in Australia, the Pacific Islands and Asia as far west as Oman. S. exempta, the nutgrass armyworm (NAW), ranges from Africa to Australia and is established in Hawaii. S. mauritia, the lawn armyworm (LAW), is found in Madagascar, scattered parts of Africa including Saudi Arabia, Asia (from Pakistan to Australia), the Pacific Islands, and Hawaii. Of the minor pests, S. pecten is in Asia, S. ochrea is in Peru, S. marima is in Brazil, while S. cilium, the grasslawn armyworm, and S. triturata are in Africa.

S. littoralis and S. litura are polyphagous feeders, utilizing a wide variety of hosts. S. cilium and S. exempta are more restricted, with preferences for cereals and pasture grasses. S. abyssinia, S. mauritia, S. pecten, and S. triturata prefer rice, corn and sugarcane.

Damage is caused by the larvae of these moths. These larvae usually feed on leaves, especially young tender leaves of the host. They may also feed on growing points, young shoots, stalks, bolls, buds, and fruits, often gnawing holes or laying sections bare, which then allows disease or rot to enter the host.

Development from egg to adult for S. littoralis with constant optimum temperatures of 86 °F for eggs, 77 °F for larvae, and 68 °F for pupae takes a minimum of just over 19 days. Such a short developmental time is not generally attained, and a more likely average is 70 days. Other species have a similar life cycle. As diapause (or aestivation) is known to occur in only a few of the species listed, the ecological overwintering range for most Spodoptera spp. should be limited to the west coast through the lower Southwestern and Southeastern States up to Maryland. Migratory species may be capable of periodic spread into Northern States and even Canada by late summer or early fall. The presumed ecological range and major hosts of S. littoralis, if established in the United States, is given as an example.

Spodoptera littoralis

C. Life Cycle Application

Insect development is temperature dependent. Egg, larval, and adult reproductive development are influenced by air temperatures. Pupal development is influenced by soil temperatures. In both environments, there is a minimum temperature threshold below which no measurable development takes place. A developmental model that uses modified air temperature data for all life stages can be used to predict the entire life cycle. The temperature for these developmental thresholds has been determined for a number of Spodoptera. The number of degrees accumulated above the

developmental threshold each day is called day degrees (DD). For the air temperature model depicted in the following table, a specific number of DD must be accumulated before one life cycle has been completed.

Formula:

Minimum Daily		Maximum Daily		Daily Total	Average Daily		Developmental Temperature Threshold		Day Degrees
Temp ^{o}F	+	Temp ^{o}F	=	$\frac{\text{Temp } ^{o}\text{F}}{2}$	= Temp ^{o}F	-	Temp ^{o}F	=	Temp ^{o}F DD

Example for Spodoptera littoralis: (Air model using a 55.4 threshold limit).

Minimum Daily		Maximum Daily		Daily Total	Average Daily		Threshold		Day Degrees
75 ^{o}F	+	86 ^{o}F	=	$\frac{161 \ ^{o}\text{F}}{2}$	= 80.5 ^{o}F	-	55.4 ^{o}F	=	25.1 ^{o}F DD

The following are known developmental thresholds and accumulated DD for two exotic Spodoptera.

S. littoralis
Threshold: 55.4 ^{o}F
Day Degrees (egg to adult)
865.04 ^{o}F male
822.56 ^{o}F female

S. litura
Threshold: 50.5 ^{o}F
Day Degrees (egg to egg)
979.34 ^{o}F

It should be noted that the kind of host consumed by a given larva can result in wide variations; thus the model must be used with caution.

Program actions are guided in part by the insect life cycle data. Eradication treatments, length of trapping activities, and regulatory functions are affected primarily by the length of time it takes to complete each phase of the life cycle. Unforeseen delays or accelerations in completion of the life cycle must be anticipated.

Temperature data are available from the National Oceanic and Atmospheric Administration, U.S Department of Commerce, private, State, university, or industry sources, or are generated by strategically placed soil probes and thermometers. If available, electronic temperature recording equipment should be used.

II. SURVEY PROCEDURES

Survey procedures will vary depending on the Spodoptera species involved and the availability of a pheromone. Since it is difficult to determine if any of the nonmigratory species would be migratory under North American conditions, all species are assumed to be migratory.

A. Delimiting Survey

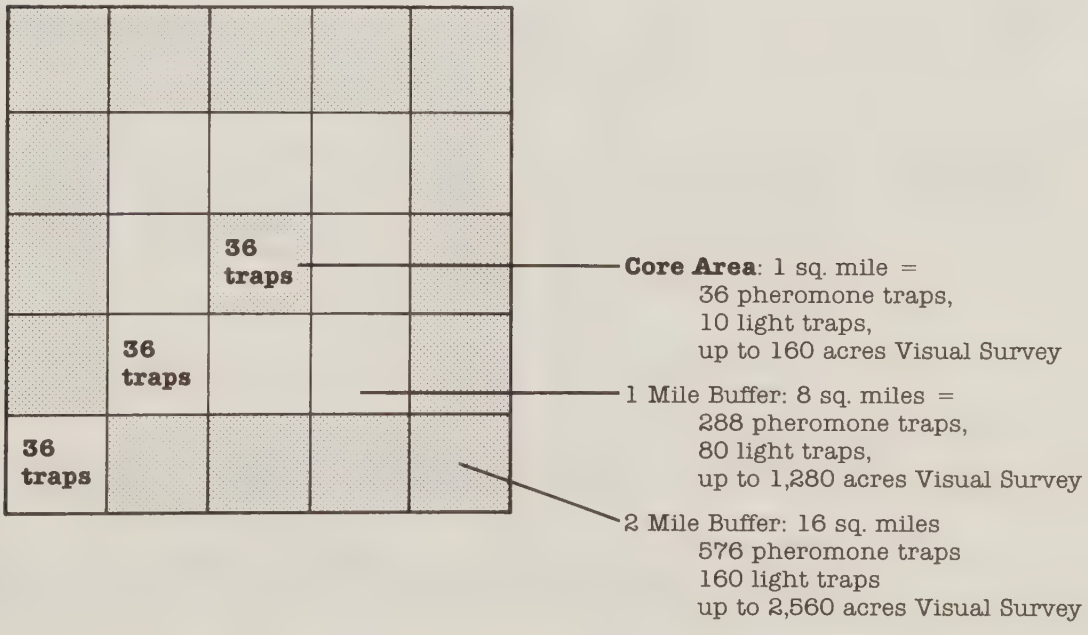
A delimiting survey must be initiated before attempting a full-scale eradication.

1. There are two primary delimiting survey systems (trapping and visual) which must be used to complement each other if an exotic Spodoptera infestation is to be adequately delimited.

When one or more exotic Spodoptera are collected in an area in which it is felt they originated, as determined by the presence of larvae, detections of a sufficient number of adults, backtracking, or other means, then a delimiting survey will be implemented immediately to determine the population distribution.

Criteria for determining the extent of survey operations are as follows:

Traps Set Per Square Mile



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a. If one or more detections are made within a 1-square mile (mi^2) area, the delimiting survey will be conducted over 9 mi^2. Traps will be deployed as shown in the core area and 1-mile (mi) buffer. A visual survey will be completed in the core area and in the first buffer at the rate of up to 160 acres (a) per mi^2.

b. If one or more detections are made in an area involving 6 mi^2 or more, the delimiting survey will be conducted over a 25-mi^2 area. Traps will be deployed as shown in trap diagram. A visual survey will be carried out throughout the 25 mi^2.

When pheromone traps are employed, blacklight traps may be added as a supplement near each detection and at selected locations in the core and buffer areas where large numbers of hosts are found.

B. Monitoring/ Evaluation Survey — A monitoring/evaluation survey will be conducted in that area where eradication treatments are applied. The traps and visual survey systems are maintained at the delimiting rate.

C. Host Collection and Holding — Selected hosts that are collected with eggs or first to third instar larvae may be held at temperatures and humidity which will permit insect development to the adult stage so that a positive identification can be made.

Security of the facility where the insects are held must be equal for a quarantine insect-rearing facility as given in APHIS publication, series 81, number 61.

D. Optional Soil Survey — This survey is designed to locate larvae and pupae in the soil. This type of survey will only be used as a last resort to verify the existence of an infestation.

E. Full Cover Detection Survey — The area beyond the second buffer, up to 10 mi from the core area is trapped at a minimum rate of nine pheromone traps or two blacklight traps per mi^2 for two life cycles. A visual survey of at least one field per mi^2 will also be conducted in this area for two life cycles.

Backtracking will be carried out if it is suspected that the find or finds are not in the original infested area.

An extended detection survey between 10 and 50 miles from the core area will compliment the detection survey.

Insofar as is possible, a National survey by all other area, State, Regional and National survey programs will back up the detection survey.

F. Orientation of Survey Personnel — New personnel will be trained, on the job, by experienced personnel. Three working days will be necessary to teach the many important facets of the Spodoptera survey.

G. Survey Records — Records noting the areas surveyed, sites trapped, dates, locations, and hosts from which detections were made will be maintained (see Addendum G).

III. REGULATORY PROCEDURES

A. Instructions to Officers

Regulatory actions will be required until the pest is eradicated. Officers must follow instructions for regulatory treatments or other procedures when authorizing the movement of regulated articles. Understanding the instructions and procedures will serve as a basis for explaining such procedures to persons interested in moving articles affected by the quarantine and regulations. Only authorized treatment procedures may be used.

General instructions that are to be followed in regulatory treatments are found in the PPQ Treatment Manual.

B. Regulated Articles

1. Those fresh fruits, nuts, vegetables, and berries listed in Addendum C which exist in the regulated area, will be listed as regulated articles.

2. The following are regulated articles for all Spodoptera species:

a. Soil within the drip area of host plants.

b. Any other product, article, or means of conveyance of any character whatsoever when it is determined by an inspector that they present a hazard of spread of Spodoptera spp. and the person in possession thereof has been so notified.

C. Quarantine Actions

Regulatory action will be required if:

1. More than one moth is found in an area less than 6 mi^2 within one estimated life cycle, or

2. One mated female, or larva, or pupa are detected, or

3. A single moth is found which is determined to be associated with a current eradication project.

When detections are made, implement the following steps:

a. Issue Emergency Action Notifications (PPQ Form 523) to all growers and establishments that grow, handle, or process regulated articles within 2.5 mi of the epicenter.

Emergency Action Notifications and/or comparable State notifications are issued by field personnel to the property owners or managers of all establishments handling, moving, or processing articles capable of spreading Spodoptera moths. Notifications will be issued pending authoritative confirmation and/or further instruction from the Deputy Administrator.

b. If necessary, the Deputy Administrator will issue a letter directing PPQ field offices to initiate specific emergency action under the Federal Plant Pest Act (7 U.S.C. 150dd) until Federal regulations can be published in the Federal Register. For other legal authorities see Section II, A and B, of the PPQ Emergency Programs Manual.

c. The Deputy Administrator will notify State cooperators through the National Regional Directors of the Spodoptera spp. detection, actions taken, and actions contemplated.

d. A narrative description of the regulated area with support documents will be developed by the U.S. Department of Agriculture (USDA) and the State cooperator and provided to Domestic and Emergency Operations (DEO), Operational Support (OS), PPQ, National Programs. The regulated area will also be defined by the Universal Transverse Mercator (UTM) grid map marking system for use by the Project Manager The regulated area will normally be 25 mi^2.

e. APHIS will publish an interim rule explaining the Spodoptera regulations in the Federal Register. The interim rule will announce a date for submitting written comments, which shall be approximately 60 days after publication.

f. After receipt of written comments, a final determination specifying the action decided upon will be published in the Federal Register.

D. Regulated Establishments Inspection

Efforts to detect the pest within the regulated area will be made at all establishments where regulated articles are sold, grown, handled, moved, or processed. Establishments that might be involved are airports, landfill sites, processing plants, farmers' associations, produce and flea markets, nurseries, flower shops, and any other establishments that handle regulated articles. Establishments deemed to be at risk by project personnel may be trapped. Two pheromone or two blacklight traps per establishment will be set and serviced weekly if trap catches of insects are high or every 2 weeks if trap catches are low. These traps will be serviced by survey personnel.

E. Use of Authorized Chemicals

The PPQ Treatment Manual and this Action Plan contain the authorized chemicals, methods and rates of application, and any special application instructions. Concurrence by the DEO, OS, PPQ, is necessary for the use of any other chemical any other chemical or procedure for regulatory purposes.

F. Approved Regulatory Treatments

Approved regulatory treatments will be as given in Section IV.C, Eradication Procedures or as determined by program management and/or a Technical Advisory Committee.

1. Fumigation. The application of an approved fumigant as a treatment.

2. Fumigation/Cold Treatment. The application of an approved fumigant in conjunction with cold treatment procedures.

3. Sanitation. The removal and destruction of leaves, flowers, stems, stalks, rotting or fallen fruit, vegetables, and other host material.

4. Insecticide Treatment. An approved ovicide/larvicide treatment applied to above ground parts of all nursery stock which may be hosts.

5. Soil Treatment. An approved insecticide applied to the soil within the dripline of host plants. Plants must be held for one life cycle after treatment before certification.

G. Principal Activities

The following identifies principal activities necessary for conducting a regulatory program to prevent the spread of Spodoptera. The extent of regulatory activity required is dependent on the degree of infestation. For example, safeguarding vegetable stands throughout the entire regulated area which are engaged in only local retail activity may not be necessary when the regulations that are imposed are based on a limited and light infestation. Mandatory checks of passenger baggage (i.e., for vegetables) at airports and the judicious use of road patrols and roadblocks may be necessary where general or heavy infestations occur.

1. Advising regulated industry of required treatment procedures.

2. Supervising, monitoring, and certifying commodity treatments of commercial lots of regulated articles.

3. Contact visits with:

   a. Security and airline personnel;
   b. Vegetable stands;
   c. Flower stands;
   d. Local growers, packers, and processing plants;
   e. Farmer's associations, produce markets, and flea markets;
   f. Commercial haulers of regulated articles;
   g. Public transportion; and
   h. Post offices.

4. Visiting canneries and other processing establishments.

5. Monitoring the movement of waste material to and from landfills to ensure adequate disposal of regulated articles.

6. Monitoring the movement of regulated articles through major airports and other transportation centers.

7. Observing major highways and quarantine boundaries for movement of host materials.

H. Removing Areas From Quarantine

Areas placed under regulation may be removed from quarantine requirements after the Spodoptera has been declared eradicated. Project management will identify areas to be removed at such time that three Spodoptera life cycles have been completed since the last specimen recovery. One life cycle must have elasped since the cessation of control activities. APHIS will publish a Notice of Quarantine Revocation in the Federal Register when areas are removed from quarantine requirements.

I. Orientation of Regulatory Personnel

Only trained or experienced personnel will be used initially. Replacement personnel will be trained by the individual being replaced. A training period of up to 3 working days is necessary for the orderly transfer of these functions.

J. Regulatory Records

Records will be maintained as necessary to carry out an effective, efficient, and responsible regulatory program. See Addendum G of this Action Plan for detailed instructions.

IV. ERADICATION PROCEDURES

The DEO, in consultation with methods and research agencies, will outline treatments to be used and must be notified of all treatment plans. If treatments selected or proposed are not in conformance with current pesticide labels, an emergency exemption can be provided under Section 18, or 24(c), special local need (SLN), of FIFRA, as amended. For further instructions, see Emergency Programs Manual, Section V.B.

Eradication of an exotic Spodoptera infestation in the continental United States is essential. The following provides approved procedures available for use in most situations. These procedures include mechanical, chemical, and biological control. Local conditions will determine the most acceptable procedure or combination of procedures for achieving eradication.

A. Eradication/ Control Method Selection

The following criteria will provide guidance for the selection of appropriate treatments to achieve eradication. Treatments suggested are the minimum recommended response to the criteria. Additional treatments can be applied if mutually agreed upon by cooperating agencies. Eradication measures will continue for at least two Spodoptera life cycles. Trapping to verify eradication will continue for at least one Spodoptera life cycle after eradication measures have stopped.

1. When one to five mated females, larvae, or pupae, or two to five males/unmated females are detected in an area of less than 6 mi^2, sanitation, host destruction, wild host clearance, and ground applied foliar sprays will be employed and extend 200 yards (yd) beyond any known detection. Similar detections in a commercial production area may also require treatment by aerial sprays.

2. When six or more of any stage(s) are detected or the infested area is greater than 6 mi^2, ground and aerial applications will be employed and extend 2 1/2 mi beyond any known detection. Sanitation, wild host clearance, and host destruction will only be employed adjacent to finds and where practical. The plowing under of hosts will be carried out in commercial production areas.

B. Recommended Pesticides

The treatments prescribed are predicated on an adequate survey. At the initiation of a program, an evaluation of available insecticides for use on program operations will be made. If pesticide resistance or tolerance is not suspected

in the target population as may be determined by the species or variety involved or by some evidence that the form involved does not come from an area where resistance or tolerance is a problem, then the following initial treatments should be applied immediately upon discovery of an exotic Spodoptera infestation. Treatments should be applied in the late afternoon, evening, or at night due to the nocturnal habits of adults and most larvae. The following is a list of pesticides that should be effective in eradicating a Spodoptera infestation:

1. Sulprofos
2. Chlorpyrifos
3. Methomyl
4. Thiodicarb
5. Flucythrinate
6. Chlordimeform
7. Fenvalerate
8. Cypermethrin
9. Diflubenzuron
10. Triflumuron
11. Petroleum oil
12. Bacillus thuringiensis
13. Trichlorfon

Up to two estimated generations may be treated with one or any combination of these insecticides. If treatment is required beyond the second generation, it will be necessary to rotate applications of different insecticides to prevent the buildup of resistance. The rotation of such treatments may continue for another four generations.

If treatments are required beyond the sixth estimated generation and/or strong resistance is known or suspected in the target population, the following sequence will be applied, and rotated in successive applications (see Section IV.B.4. Special Applications).

Insecticide + Insecticide/Synergist
Insecticide + Inhibitor
Biological + Phagostimulant/Insecticide

C. Approved Eradication Treatments

1. Confined (Indoor) Situations

Where confirmed infestations, in whole or in part, are found indoors in nurseries or greenhouses, application of insecticide will be initiated immediately. All plants within the enclosure will be treated to eliminate hiding places for the adult as well as to kill any larvae present on host plants. Spray applications shall be directed to the underside of leaves where larvae congregate and to drench the soil just under each plant/host where older (3rd to 4th instar) larvae hide during the day.

The following insecticides may not be registered for this use. Any application inconsistent with product labeling must have an exemption and prior approval. Read the label and use the highest dosage available for that particular

crop and pest.

Chlorpyrifos (Dursban)--Apply as a full-coverage spray. Repeat at 3- to 7-day intervals. Avoid runoff.

Methomyl (Lamnate)--Apply as a full coverage spray. Repeat at 5- to 10-day intervals. Avoid runoff.

Methyl bromide--Tarpaulin fumigation. Use with caution due to possible toxicity to plants.

Sulprofos (Bolstar 6)--Apply as a full-coverage spray. Repeat at 3- to 7-day intervals.

Thiodicarb (Larvin SC)--Apply as a full-coverage spray. Repeat at 3- to 7-day intervals.

2. Outdoor Residential or Commercial Situations

Ground application of insecticide will be initiated immediately. Treat all hosts plants which provide for reproduction of the Spodoptera on the infested property, adjacent property, and a minimum of 1/4 mi beyond the known infestation. Spray applications should, when possible, be directed to the underside of leaves where larvae congregate and to drench the soil under hosts where older (3rd to 4th instar) larvae may hide during the day. Ground spraying may be discontinued after an estimated two generations of negative survey or after the initiation of aerial treatment.

Aerial spray will be applied when and where ground treatment is not practical. Aerial applications for Spodoptera are best carried out by helicopter, as the downdraft turns the leaf surface for better exposure. Application will be made at the prescribed intervals over a minimum period equal to two life cycles after the last find. The area to be sprayed will extend a minimum of 2 1/2 mi beyond any known infestation.

The following insecticides may not be registered for ground or aerial spray. Any application inconsistent with product labeling must have an exemption and prior approval. Read the label and employ the highest dosage available for that particular crop and pest.

Chlordimeform (Fundal 4 SP)--Apply as a full-coverage spray when eggs and young larvae are present. Repeat at 3- to 5-day intervals.

Chlorpyrifos (Lorsban 4 E)--Apply as a full-coverage spray. Repeat at 7- to 10-day intervals.

Cypermethrin (Cymbush)--Use only as a tank mix with other insecticides against Spodoptera. Repeat at 5- to 7-day intervals.

Diflubenzuron (Dimilin 25 W) -Apply as a full-coverage spray in a tank mix with other insecticides or interspersed with other treatments. Use when eggs and young (1st to 3rd instar) larvae are present. Repeat at 7- to 14-day intervals. An inhibitor with ovicidal activity.

Fenvalerate (Pydrin 2.4 EC)--Apply as a full-coverage spray. Repeat at 5- to 10-day intervals.

Flucythrinate (Payoff)--Apply as a full-coverage spray. Repeat at 3- to 4-day intervals.

Methomyl (Lannate L)--Apply as a full-coverage spray. Repeat at 3- to 7-day intervals. Possesses good ovicidal and larvicidal activity.

Sulprofos (Bolstar 6)--Apply as a full-coverage spray. Repeat at 3- to 7-day intervals.

Thiodicarb (Larvin SC)--Apply as a full-coverage spray. Repeat at 3- to 7-day intervals.

Trichlorfon (Dylox 80 percent SP)--Use only with Bacillus thuringiensis (Bt) as a tank mix against Spodoptera larval stages. Apply as a spray with Bt at 15-day intervals when larvae are present.

Triflumuron (Alsystin 25 percent WP)--Apply as full-coverage spray with other insecticides in a tank mix or interspersed with other treatments. Use when eggs and young (1st to 3rd instar) larvae are present. Repeat at 7- to 14-day intervals. A strong inhibitor with good ovicidal activity. No current U.S. registration.

4. Special Applications

The following treatments may be considered when problems arise in the control or eradication of resistant Spodoptera infestations.

a. Insecticide Combinations - Synergists

The insecticide combinations listed below have been selected to enhance insecticide performance, particularly against resistant strains. Use mixtures at the lowest rates recommended for these products but observe the most restrictive of safety precautions given on the labels.

Chlordimeform + Sulprofos
Chlordimeform + Cypermethrin
Chlordimeform + Flycythrinate
Chlordimeform + Methomyl
Chlorpyrifos + Sulprofos
Chlorpyrifos + Fenvalerate
Chlorpyrifos + Cypermethrin
Cypermethrin + Methomyl
Fenvalerate + Methomyl

The synergist-insecticide combinations given here have been shown to be the most effective against resistant strains. Add as much synergist (technical concentration) as insecticide (1:1) by volume.

Chlorpypiphos + piperonyl butoxide
Chlorpypiphos + bucarbolate
Fenvalerate + piperonyl butoxide
Flucythrinate + piperonyl butoxide
Methomyl + piperonyl butoxide
Methomyl + bucarbolate

b. Insecticide/Inhibitor

The insecticide/inhibitor tank-mix combinations listed in this section may be employed against Spodoptera. Inhibitor applications may be interspersed between applications of any of the other insecticides. Use mixtures at the lowest rates recommended for these products, but observe the most restrictive of safety precautions given on the labels.

Diflubenzuron + Chlordimeform
Diflubenzuron + Fenvalerate
Diflubenzuron + Cypermethrin
Triflumuron + Fenvalerate
Triflumuron + Cypermethrin
Triflumuron + Chlordimeform

c. Antifeedent

At present, the application of 2 percent Neem Kernel suspension has been found to be effective against Spodoptera larvae. This can used in biologically sensitive areas where chemical control is not feasible. It may also be employed after chemical applications but not after biological applications, since this treatment inhibits feeding. Heavy populations should not be treated since it is possible a larval migratory reaction could result. This treatment is also subject to the availability of Neem extract.

d. Biological

The following applications have been shown to be useful against Spodoptera. When possible, obtain Bt biotypes that are specific for a given Spodoptera species. Biological applications should cover both sides of the leaves. If applied aerially, it should be done by helicopter since the downdraft turns the leaf surfaces for better exposure. These biological preparations can be used in biologically sensitive areas or in urban areas where chemical control may not be feasible.

Bacillus thuringiensis (Dipel 16 L)--Commonly referred to as Bt. Apply as a full-coverage spray when 1st to 3rd larvae are present. Repeat at 10- to 14-day intervals while larvae are active. Check current information, since more active and more specific Bt formulations may be available.

e. Biological/Insecticide Combinations

The following combinations have been selected to enhance insecticide performance with biological activity. These combinations should be used against resistant strains of Spodoptera. Use mixtures at the lowest rates recommended for these products, but observe the most restrictive safety precautions given on the labels.

Bt + Trichlorfon
Bt + Cypermethrin
Bt + Fenvalerate
Bt + Chlordimeform

After an estimated two generations of negative trapping and survey, spray operations may be discontinued.

The objectives are to eradicate the pest and minimize environmental contamination. Any treatment or retreatment recommendation must consider these objectives. Treatment or retreatment should be considered if weather reports indicate 50 percent or greater change of precipitation within 48 hours. The decision to apply insecticides will be based on the best weather information available. In the event rain washes an application from the foliage, plans will be implemented to retreat the area.

5. Supplemental Methods

a. Host Destruction: In situations with a very limited area of infestation, consideration will be given to the destruction of host by (1) herbicides, (2) disking or plowing, and (3) removal and burial or incineration. In cases of such destruction, all host material must be completely destroyed.

b. Sanitation: Sanitation in nurseries, farms, gardens, and other establishments where hosts are present will be carried out within the core and buffer areas. Sanitation will consist of the following measures to be applied depending on the circumstances and equipment available.

(1) Burning of Debris

When host material is collected, it may be piled into heaps and burned if local ordinances permit. The residue can be disked under or otherwise buried in an approved landfill.

(2) Grass and Weed Control

When possible, grasses and weeds growing along roadsides, fields, or in row crops should be kept down by cultivation. At time of pupation or estimated pupation, the soil should be lightly plowed or cultivated to destroy pupae.

(3) Animal Food

Some kinds of host material may be used as animal food. Any residue will be disposed of by burning and/or burial at an approved landfill.

(4) Bagged and Buried

Host material may be collected in suitable containers and transported to an approved landfill.

(5) Vehicle Inspection/Cleaning

Vehicles, trucks, wagons, etc., used in host fields or to transport host material must be inspected to ensure that accidental movement of host material with eggs or larvae or of loose larvae does not occur. Cleaning consists of the removal and destruction of any host material/eggs or larvae found.

c. Soil Treatment: Soil treatment can be used to kill larvae and emerging adults. Treat the soil under all hosts or suspected hosts on properties where eggs, larvae, or pupae have been found. Treat the soil within 200 yd of each find.

The following insecticide may not be registered for this use. Any application inconsistent with product labeling must have an exemption and prior approval.

Chlorpyrifos (Lorsban 10 G)--Make two applications 1 month apart and repeat sequence every 4 months.

d. Flooding

If a field can be flooded, this may be employed in preference to chemical controls. The water should be allowed to remain on the field for at least 2 days.

e. Crushing

Larvae may be destroyed by using a steel lawn roller over smooth lawns. Since this technique is not 100 percent effective, it can be only be employed in conjunction with other control measures.

f. Barriers

If a heavy infestation is evident and larvae disperse (armyworm march), they should be headed off by plowing a deep furrow around the infested area or field (if possible). The furrow should have straight sides to prevent larvae from crawling out. Postholes at least 1 foot (ft) deep are placed 20 ft apart in the furrow. Larvae will collect in these postholes and can be disposed of with soapy water or kerosene. Furrows must be kept clear of rubbish. This technique is labor intensive and should be employed in conjunction with other control measures only at times of actual migration in limited areas.

E. Orientation of Eradication/Control Personnel

Only trained and experienced personnel will be used initially. Replacement personnel will be trained by the individual being replaced. A training period of up to 3 working days is necessary for the orderly transfer of these functions.

F. Eradication/Control Records

Records and maps noting the locations of detections, data, number and type of treatments, and materials and formulations used will be maintained for all area treated. See Addendum G of this Action Plan for detailed instructions.

G. Monitoring

An effective monitoring program will be implemented to aid in the evaluation of program efforts and environmental impact. The application and use of pesticides will be assessed through the use of appropriate monitoring program criteria. The evalution must effectively address Agency, cooperator and public concerns.

The monitoring program will include at least the following elements:

1. Determine efficacy of pesticides against the target pest.

2. Evaluate dye cards to monitor aerial applications.

    a. Droplet size information
    b. Droplet distribution information
    c. Bait distribution information
    d. Identification of wind drift components
    e. Verification of spray block boundaries and
    f. Identification of skips.

3. Sample to evaluate effect on environmental components.

    a. Water sampling to detect insecticide levels resulting from direct application, leaching, and runoff
    b. Soil sampling to determine insecticide levels and residues
    c. Foliage sampling to identify residues
    d. Biological organism sampling before, during and after applications and posttreatments to determine impact of pesticides and
    e. Air sampling to determine presence of pesticides

The monitoring program is to be a combined effort between the State in which the emergency program is being conducted and PPQ. Specific plans will need to be developed for monitoring activities and the DEO Staff will request assistance and guidelines from the Policy and Program Development Staff.

V. CONTACTS

When an exotic Spodoptera eradication program has been implemented, its success will depend upon the cooperation, assistance, and understanding from other involved groups. The following is a list of groups which are either directly involved or need to be informed of all operational phases of an emergency program.

1. Other Federal, State, county, and municipal agricultural officials
2. Grower groups
3. Commercial interests
4. Universities
5. State and local law enforement officials
6. Public health agencies
7. Foreign agricultural interests
8. National, State and local news media
9. The general public and
10. Post office contacts.

VI. ADDENDA

Addendum A--Definitions

Aerial Treatment:	Applying an insecticide by aircraft over a treatment area.
Array:	The trapping pattern in a 1-mi^2.
Array Sequence:	The trapping pattern (array) beginning with the core area and continuing outward through each buffer area ending with the other buffer area.
Block:	In detection surveys, a 1-mi^2 area chosen to conduct all aspects of a survey.
Buffer Area:	The area extending beyond the boundary of the core --the 1- and 2-mi buffers within the regulated area, and the extended buffer area up to 50 miles from the core.
Cold Treatment:	The use of cold temperatures as a treatment on selected products alone or in conjunction with fumigation procedures.
Commercial Production Area	An area where host material is grown for commercial distribution.
Confirmed Detection:	A positive idenfication by a recognized expert of a submitted life form (specimen) as an exotic Spodoptera.
Core Area:	An area of 1 mi^2 surrounding a confirmed exotic Spodoptera detection.
Day Degrees:	An accumulation of heat units above a developmental threshold.
Delimiting Survey:	Determining whether an infestation exists and if so, the extent of the infestation in an area where an exotic Spodoptera has been detected.
Detection:	The collection of any life stage of an exotic Spodoptera.
Detection Survey:	An activity conducted in a susceptible area not known to be infested with exotic Spodoptera.
Developmental Threshold:	The minimum (or maximum) temperature below (or above) which physiological development stops (peaks).
Epicenter/Focal point:	The initial site of an infestation.

Exotic Spodoptera:	A species of Spodoptera not native to or resident in North America.
Fumigation	The application of an approved fumigant (methyl bromide) as a treatment alone or in conjunction with cold treatment procedures.
Generation: (Life Cycle)	The period of time for the pest to complete all stages of development.
Ground Spray:	Using ground spray equipment to apply an insecticide to host vegetation in an infested area.
Host:	A plant species that provides for reproduction of an exotic Spodoptera.
Host Collection/ Holding	The collection and holding of host material to determine the extent and nature of the infestation.
Infestation:	The collection of two or more exotic Spodoptera, a pupa, a larva, or mated female from an area, or the detection of a single adult associated with a current infestation.
Infested Area:	An area of 2 1/2 mi around all detection sites unless biological factors indicate the need for more or less area.
Light Trap:	A trap with a special bulb radiating light in wavelengths attractive to moths.
Migratory Species:	A species in which the female regularly flies some distance before laying eggs or mating and laying eggs.
Monitoring/Evaluation Survey:	Using interdependent visual and trapping surveys conducted in an area where an insecticide treatment has been applied to evaluate the effectiveness of the application.
Nonmigratory Species:	A species in which the female normally mates and lays most of her eggs in a local area.
PPQ-APHIS-USDA:	Plant Protection and Quarantine, Animal and Plant Health Inspection Service, United States Department of Agriculture.
Regulated Area:	An area that extends at least 2 1/2 mi in any direction from the epicenter of an infestation.
Regulated Articles:	All known or suspected hosts of a confirmed infestation of an exotic Spodoptera species, including soil and any other suspected product or article.

Regulatory Survey:	Trapping conducted around establishments where regulated articles are sold, handled, processed or moved.
Sex Pheromone:	A pheromone which will attract the male of a given species of Spodoptera.
Soil Treatment:	The application of an approved insecticide to the soil of nursery stock or within the dripline of host plants.
Spodoptera:	The scientific name for a genus of moths. Specific species are given in the text.
Trap Survey:	Determining the presence or absence of a pest by the use of traps and an attractant placed in a predetermined pattern and serviced on a given schedule.
Visual Survey:	Examining areas for eggs, larvae, and cocoons either in the field or in regulated establishments.
Wing Trap:	A disposable, sticky-coated trap used primarily for attracting moths.
Urban/Residential Area:	An area containing multiple- or single family dwellings.

Addendum B--Safety

Personnel and public safety must be prime considerations at all times. Safety practices should be stressed in preprogram planning and through the duration of actual program operations. Supervisors must enforce on-the-job safety procedures. For complete insructions, See Section V.D., in the Emergency Programs Manual.

Addendum C--Hosts

The known hosts of most exotic Spodoptera are listed below. For some species the natural host range is not well known. In addition, the polyphagous species are very likely to have a wide range of new hosts in North America.

1. Spodoptera littoralis

The Egyptian Cottonworm (ECW) is a general feeder on hosts belonging to 44 families. These include crucifers, deciduous fruit trees, grasses, legumes, medicinal crops, ornamentals, and many vegetables. Eight families have more than 50 percent of the known hosts. In decreasing numbers of hosts, these families are: Leguminosae, Solanaceae, Malvaceae, Moraceae, Compositae, Gramineae, Chenopodiaceae, and Cruciferae.

The ECW host list is separated into preferred and other recorded hosts. The preferred hosts include those hosts which are accepted by the larvae, which support their growth, or which are accepted for oviposition and food. Hosts for which documentation is not available in one or more of these categories or in which no tests have been carried out are placed in the "other" list.

It should be borne in mind that plant species other than those listed will eventually prove to be hosts if the ECW should be established in this country. Such plants will most likely include many common wild species as well as hosts of ornamental or economic value.

PREFERRED

Common Name	Scientific Name
Beet	Beta vulgaris
Berseem (clover)	Trifolium alexandrinum
Brussels-sprouts	Brassica oleracea gemmifera
Cabbage	Brassica oleracea
Carrot	Daucus carota sativus
Castor	Ricinus communis
Cauliflower	Brassica oleracea
Corn	Zea mays
Cotton	Gossypium barbadense (G. hirsutum)
Eggplant	Solanum melongena
Finger millet	Eleusine coracana
French beans	Phaseolus vulgaris
Garden pea	Pisum sativum
Grape	Vitis vinifera
Guava	Psidium guajava
Jew's mallow	Corchorus olitorius
Kidney beans	Phaseolus vulgaris
Lettuce	Lactuca sativa
Millets	Pennisetum spp.

Okra	Hibiscus esculentus
Peanut	Arachis hypogaea
Potato	Solanum tuberosum
Radish	Raphanus sativus
Red pepper	Capsicum annum
Sesban	Sesbania aegyptiaca
Spinach	Spinacia oleracea
Sweet melon	Cucumis dudaim
Sweet potato	Ipomoea batatas
Tomato	Solanum lycopersium
Watermelon	Citrullus vulgaris
White poplar	Populus alba

No Common Name

Cineraria hybrida

OTHER

Common Name	Scientific Name
Apple	Pyrus malus
Arbor-vitae	Thuja orientalis
Aster	Callistephus chinensis
Banana	Musa paradisiaca
Bindweed	Convolvulus spp.
Blue clitoria	Clitoria ternatea
Broad bean	Vica faba
Cacao	Theobroma cacao
Cassava	Manihot utilissma
Casuarina	Casuarina equisetifolia
Changeable rose	Hibiscus mutabilis
Chempedak	Artocarpus integer
Citron	Citrus medica
Coconut	Cocos nucifera
Coffee	Coffea arabica
Colocasia	Arum colocasia
Common Mallow	Malva sylvestris
Cowpea	Vigna sinensis
Custard-apple	Annona squamosa
Date palm	Phoenix dactylifera
Egyptian carissa	Carissa edulis
Eucalyptus	Eucalyptus globulus
Feather asparagus	Asparagus plumosus
Fenugreek	Trigonella foenum-graecum
Fig	Ficus carica
Flowering reed	Canna indica
Gerocorn	Penicillaria spicata
Gum-arabic	Acacia arabica

Hemp	Hibiscus cannabinus
Hollyhock	Althaca rosa
Horseradish tree	Moringa deifera
Indigo	Indigofera tinctoria
Jute	Corchorus capsularis
Lantana	Lantana salvifolia
Lucerne	Medicago sativa
Mallow, small flowered	Malva parviflora
Mandarin orange	Citrus aurantium
Mango	Mangifera indica
Mint	Mentha sativa
Night jasmine	Cestrum nocturnum
Onion	Allium cepa
Oxalis	Oxalis crenata
Papaya	Carica papaya
Pigeon pea	Cajanus indicus
Plum	Prunus domestica
Pomegranate	Punica granatum
Poppy	Papaver somniferum
Pricklylettuce	Lactuca scariola
Pricklypear	Cactus opuntia
Purslane	Portulaca oleracea
Rice	Oryza sativa
Rose	Rosa spp.
Sacred fig	Ficus religiosa
Sand pear	Pyrus pyrifolia
Shallots	Allium ascalonicum
Sissoo Tree	Dalbergia sissoo
Small flowered mallow	Malva parviflora
Snakeweed	Polygonum glabrum
Sodum apple	Solanum sodeomeum
Sorrel	Rumex sesicarius
Soya bean	Glycine max
Sugarcane	Saccharum officinarum
Sunflower	Helianthus annuus
Sweet-william	Dianthus barbatus
Sycamore fig	Ficus variegata
Tea	Thea sinensis
Tobacco	Nicotiana tabacum
Turnip	Brassica rapa
Turnip rooted celery	Opium graveolens
Violet	Viola odorata
Wall goose-foot	Chenopodium murale
Wheat	Triticum vulgare
White datura	Datura spp.
Zinnia	Zinna elegans

No Common Name

	Amaranthus graecizans
	Chrysanthemum indicum
	Euphorbia prunifolia

	Ficus spp.
	Sesbania aegyptiaca
	Syzygium malaccense

2. Spodoptera litura

The Rice Cutworm (RCW) is a general feeder on over 100 hosts, not all of which are listed here. These include the crucifers, leguminosae, millets, deciduous fruit trees, and various flowers and vegetables. No attempt is made to rank the listed hosts by order of preference.

Common Name	Scientific Name
Amaranth, spiny	Amaranthus viridis
Banana	Musa spp.
Beet	Beta vulgaris
Cabbage	Brassica oleracea
Castilloa rubber	Castilla elastica
Castor	Ricinus communis
Cauliflower	Brassica oleracea
Celery	Apium graveolens
Chickpea	Cicer arietinum
Chinese cabbage	Brassica pekinensis
Citrus	Citrus spp.
Clover	Trifolium spp.
Coca	Erythroxylum coca
Cotton	Gossypium spp.
Cowpea	Vigna unguiculata
Eggplant	Solanum melongena
Eucalyptus	Eucalyptus spp.
Flax	Linum usitatissimum
Gladiolas	Gladiolus spp.
Globe artichoke	Cynara scolymus
Grapes	Vitis spp.
Hemp	Cannabis sativa
Indian bean	Catalpa bignonioides
Jute	Corchorus capsularis
Lentil	Lens culinaris
Lettuce	Lactuca sativa
Lucerne	Medicago sativa
Maize	Zea mays
Mulberry	Morus spp.
Okra	Abelmoschus esculentus
Onion	Allium cepa
Papaya	Carica papaya
Peanut	Arachis hypogaea
Pigeon pea	Cajanus cajan
Potato	Solanum tuberosum
Rose	Rosa spp.
Sorghum	Sorghum bicolor

Soybean	Glycine max
Spinach mustard	Brassica rapa var.
Sweet potato	Ipomoea batatas
Taro	Colocasia esculenta
Tea	Camellia sinensis
Til	Sesamum orientale
	Sesamum indicum
Tobacco	Nicotiana tabacum
Tomato	Lycopersicon esculentum
Turmeric	Curcuma domestica
Turnip	Brassica rapa
Watermelon	Citrullus lanatus
Zinnia	Zinnia violacea

No Common Name

Chenopodium amaranticolor
Crassocephalum crepidioides
Indigofera zollingeriana
Portulaca quadrifida

3. Spodoptera exempta

The Nutgrass Armyworm (NAW) is mostly limited to grasses in the Gramineae and Cyperacease. Presumably other grass species would prove to be hosts if NAW became established in North America.

Common Name	Scientific Name
Barley	Hordeum vulgare
Cotton	Gossypium hirsutum
Finger millet	Eleusine coracana
Grass	Eleusine indica
Maize	Zea mays
Oats	Avena sativa
Rice	Oryza sativa
Sorghum millet	Sorghum vulgare
Star grass	Cynodon dactylon
Sugarcane	Saccharum officinarum
Tef	Eragrostis tef
Wheat	Triticum aestivum

No Common Name

Acidanthera laxiflora
Carpobrotus edulis
Oxygonum sinuatum

4. Spodoptera mauritia

The Lawn Armyworm (LAW) is apparently limited to Gramineae, Cyperaceae, and Typhaceae. Other species will almost certainly prove to be hosts in North America. Various grasses are said to be hosts in addition to the plant species listed here.

Common Name	Scientific Name
Alexandra palm	Archontophoenix alexandrae
Arrowroot	Canna spp.
Bamboo	Bambusa spp.
Barley	Hordeum vulgare
Bermudagrass	Cynodon dactylon
Blackeye pea	Vigna catjang
Buffelgrass	Cenchrus ciliaris
Cabbage	Brassica oleracea
Cattails	Typha spp.
Clover	Trifolium reopens
Cluster palm, a	Actinophloeus macarthuri
Coconut	Cocos nucifera
Cotton	Gossypium barbadense
Cowpea	Vigna unguiculata
Dalligrass	Paspalum dilatatum
Dragon trees	Dracaena spp.
Fescue	Festuca spp.
Finger millet	Eleusine corocana
Foxtail	Setaria sphacelata
Garden bean	Phaseolus vulgaris
Garden pea	Pisum sativum
Giant pea	Arundo donax
Goosegrass	Eleusine indica
Grass, a	Dititaria didactyla
Grasses	Digitaria henryi
Guineagrass	Panicum maximum
Irises	Iris spp.
Johnsongrass	Sorghum halepense
Kikuyu grass	Pennisetum clandestinum
Lettuce	Lactuca sativa
Lovegrass, a	Eragrostis tenuifolia
Madagascar palm	Chrysalidocarpus lutescens
Maize	Zea mays
Manilla grass	Zoysia matrella
Molasses grass	Melinia minutiflora
Nutgrass, a	Kyllinga monocephala
Nutgrasses	Cyperus spp.
Netsedge	Cyperus rotundus
Oatsya	Avena sativa
Papaya	Carica papaya
Pearl millet	Pennisetum americanum
Perennial ryegrass	Lolium perenne
Potato	Solanum tuberosum
Quickgrass	Agropyrons repens

Reeds	Phragmites spp.
Rhodesgrass	Chloris gayana
Rice	Oryza sativa
Tye	Secale cereale
Smilax	Asparagus asparagoides
Sorghum	Sorghum bicolor
St. Augustine grass	Stenotaphrum secundatum
Sugarcane	Saccharum officinarum
Tobacco	Nicotiana tabacum
Tomato	Lycopersicon esculentum
Tropical carpetgrass	Axonopus compressus
Wheat	Triticum aestivum

No Common Name

Chaetochloa verticillata
Chlorophytum spp.
Cryptomeria spp.
Cyperus gracilis
Cyperus kyllingia
Fimbristylis acuminata
Fimbristylis tenera
Isachne globosa
Ischaenum aristatum
Panicum setigerum
Paspalum conjugation
Paspalum scrobiculatum
Triodia spp.
Vitex trifolia

5. Spodoptera pecten-(No Common Name)

This species seems to be restricted to Gramineae and Cyperaceae. Records actually pertaining to this species were recorded under S. abyssini, a species now shown to belong in a different genus.

Common Name	Scientific Name
Purple nutsedge	Cyperus rotundus
Rice	Oryza sativa
Sugarcane	Saccharum officinarum

6. Spodoptera ochrea - (No Common Name)

Reported to be damaging on alfalfa.

Common Name	Scientific Name
Alfalfa	Medicago sativa
Beets	Beta vulgaris
Carrots	Daucus carota
Soybean	Glycine max

7. Spodoptera cilium - (No Common Name)

This species is believed to attack many grasses.

Common Name	Scientific Name
Bermuda grass	Cynodon dactylon
Carpet grass	Axonopus affinis
Grass, a	Digitaria didactyla

8. Spodoptera triturata - (No Common Name)

Known only from grasses and the following hosts.

Common Name	Scientific Name
Bermuda grass	Cynodon dactylon
Maize	Zea mays
Sugarcane	Saccharum officinarum

9. Spodoptera marima - (No Common Name)

Known only from grasses. It is said to be a pest, but little information is available.

Addendum D - Technical Survey Information

1. Traps

   a. Pheromone Trapping

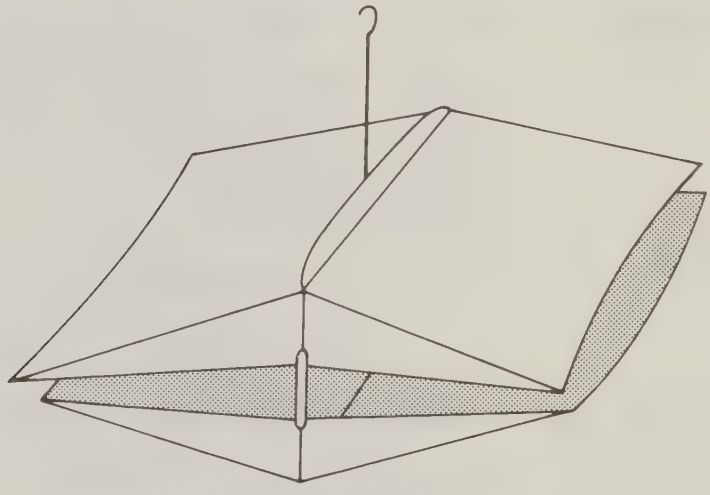
The following table lists the known pheromone requirements for each species:

Species	Migratory	Pheromone Compounds	Ratio of Compound (1) to Compound (2)
S. littoralis	No	(1) (Z, E)-9, 11-tetradecadienyl acetate (TDDA) (2) (Z, E)-9, 12-TDDA	99.5:0.5
S. litura	No	(1) (Z,E)-9, 11-TDDA (2) (Z,E)-9, 12-TDDA	88:12
S. exempta	Yes	(1) (Z)-9-TDDA (2) (Z)-9, (E) -12-TDDA	20:1
S. mauritia	No	Not known	N/A
S. cilium	No	(1) (Z, E)-9, 12 -TDDA (2) (Z)-9-tetradecenyl alcohol	10:1
S. triturata	No	(1) (Z)-9-TDDA (2) (Z, E)-9, 12-TDDA	20:1
S. pecten	No	Not known	N/A
S. abyssinia	No	Not known	N/A
S. ochrea	No	Not known	N/A
S. marima	No	Not known	N/A

When the species involved responds to a pheromone, pheromone trapping will be the method of choice. Using

the site of the detection as the focal point (epicenter), 36 stickly wing traps, Pherocon 1C of equivalent, will be set out in the core area and in each mi^2 of the first and second buffer areas in a standard grid array. The traps are baited with the appropriate pheromone as given above and serviced every week. Place traps in or near hosts. Traps will be maintained through three estimated Spodoptera generations after the last detection.

Sticky Wing Pherocon 1C Trap



spodoptera

Manufactured pheromone lures should be used whenever possible. However, if these are not available, impreg nated plastic stoppers may be used.

A polyethylene stopper 10 millimeters (MM) in diamter previously injected with 1 milligram (mg) of the appropriate pheromone is installed in each trap. This is easily done by pushing a small thumbtack through the outside of the trap and pushing the stopper onto the tack on the inside.

The traps may be hung in hosts or hung from stakes at the height of the host. As the season progresses, there may be a need to raise the trap as the host's height increases.

(b) Blacklight Trapping

When the species involved does not respond to a known pheromone, blacklight traps are used. Using the site of

the detection as the focal point. 10 blacklight traps will be set out in the 1-mi^2 core area and, when possible up to 10 traps will be set in each mi^2 of the first and second buffer. Traps are to be serviced every day. Place traps in or near hosts. Traps will be maintained through three Spodoptera generations after the last detection.

Blacklight Trap

Blacklight traps commercially available from entomological supply companies may be used. If a shortage of blacklight traps develops, other types of light traps may be used. Alternatively, the number of traps outside the core area may be reduced to one per mi^2. All traps should be properly set and timed for night operation only.

As this system is labor intensive, it is used only in the core and buffer areas in or near detections or where large numbers of hosts are found. Blacklight traps may be more effective than pheromone traps at times when there is little wind movement.

2. Visual Survey

Using the site of the detection as the focal point, locate up to 16 host fields within the mi^2 core area. Each field will be sampled at five locations. A minimum of 50 plants (10 plants from each location) will be examined for the presence of eggs and larvae as described in Addendum D. Inspect fruit, stems, young shoots, flowers, heads, and leaves for holes in leaves, gnawed tips, or holes in fruit.

Very large fields should be divided into smaller units, and each unit counted as a separate field with a maxmum of 10 a. Not all such units should be sampled at the same time, in order to keep spacing of sample fields roughly equal.

To improve survey effectiveness, it should be conducted during favorable weather and periods of insect activity. However, since most Spodoptera are nocturnal feeders, it may be necessary to conduct some visual surveys at night.

If sufficient host fields are available, the visual survey will be repeated once a week in different fields. The survey will last for at least three Spodoptera generations. Fields will be rotated to allow coverage of the entire core area over each 4-week period.

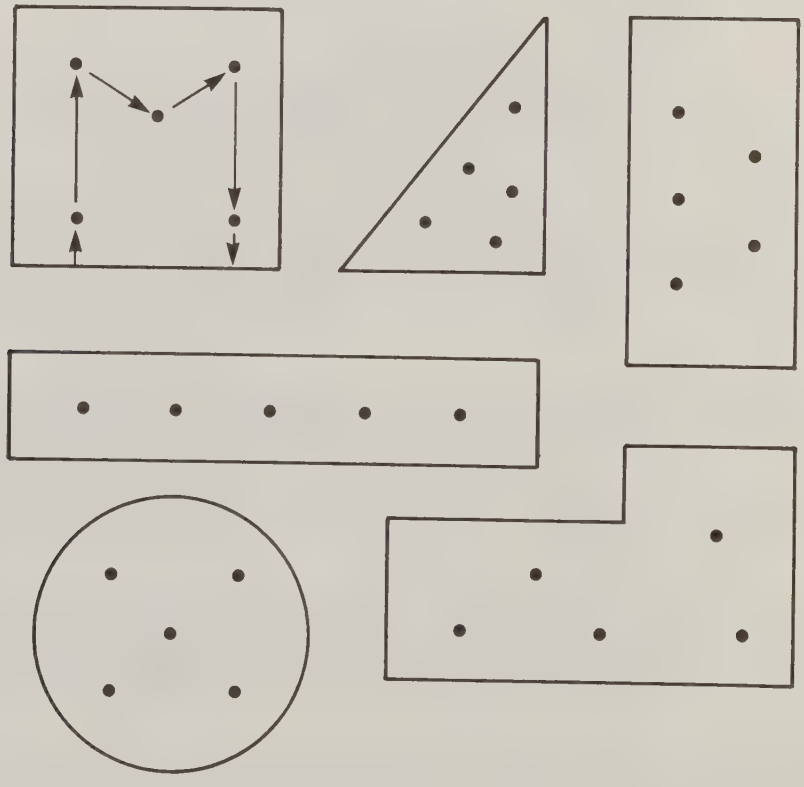
Visual Survey Procedure

Samples should be equally spaced, unless damaged areas are noted. Damaged areas with partly or completely eaten leaves or flowers, gnawed shoots, fallen stalks, fallen or rotting fruit, gnawed heads, or which exhibit poor growth, receive priority in the survey.

In addition to the above in-field survey, check borders, fence rows, and ditchbanks for suitable hosts. If suitable hosts are found, a separate survey may be taken, particularly if it is in the core area.

Sampling within the field should follow a similar pattern for each field being surveyed. When collecting samples within fields, take samples at least 75 ft from the edge from five different locations in the field. Move from location to location following a predetermined pattern such as given below.

Field Survey Pattern



At each of the five sample locations, inspect a minimum of 10 plants from three adjoining rows (or equivalent spacing if no rows are present) with a bias toward those plants showing signs of chewed leaves, poor growth, rotting, fallen fruit, holes in fruit or heads, gnawed

shoots, or fallen stalks.

Look for the following Spodoptera life stages:

Eggs: Look for clusters of 30 to 300 eggs, covered with hair scales on the underside of leaves near growing points of the host.

Larvae: Check leaves and flowers for feeding signs and young larvae. Then look at fruit or heads for gnawed, shallow holes with or without sign of decay. Stir up the soil around the base of the plant to determine if larvae are hiding in the soil and to find any pupae present. In grassy areas, look for brown patches of grass and observe if the blades have been eaten and look obviously ragged.

Adults: Sometimes adults will be found on the underside of leaves, or bark of trees, or they may be flushed from herbaceous growth.

Adults should be caught and saved for identification. Eggs and larvae will be collected with sufficient host for rearing purposes, should this prove necessary.

3. Soil Survey (Optional)

a. Soil Screening

Passing of soil through a screen for the detection of pupae. Soil samples will be collected within 200 yd of a larval or egg detection.

At least four 20 square inch (in^2), 2-inch (in) deep samples of soil are to be dug out from under the selected host and placed in a suitable container such as a plastic garbage bag. The bag is labeled before transport to the rearing/ID laboratory. Soil collected within the regulated area is a regulated article and will require certification if moved out of the regulated area.

Place soil sample in the top of a 4-mm (0.15-in) sieve and wash down with water until all the lumps are broken and only solid objects remain in the sieve. Remove any solid objects and collect the pupae. Any recovered pupae will be held until adult emergence.

b. Turfgrass Soil Sampling

This survey method requires the treating of turf with a detergent solution to force larvae out into view. At least one sample will be taken in grass within 200 yd of a larva, pupa, or egg detection. Generally, this

technique is useful only for those Spodoptera which regularly attack grasses.

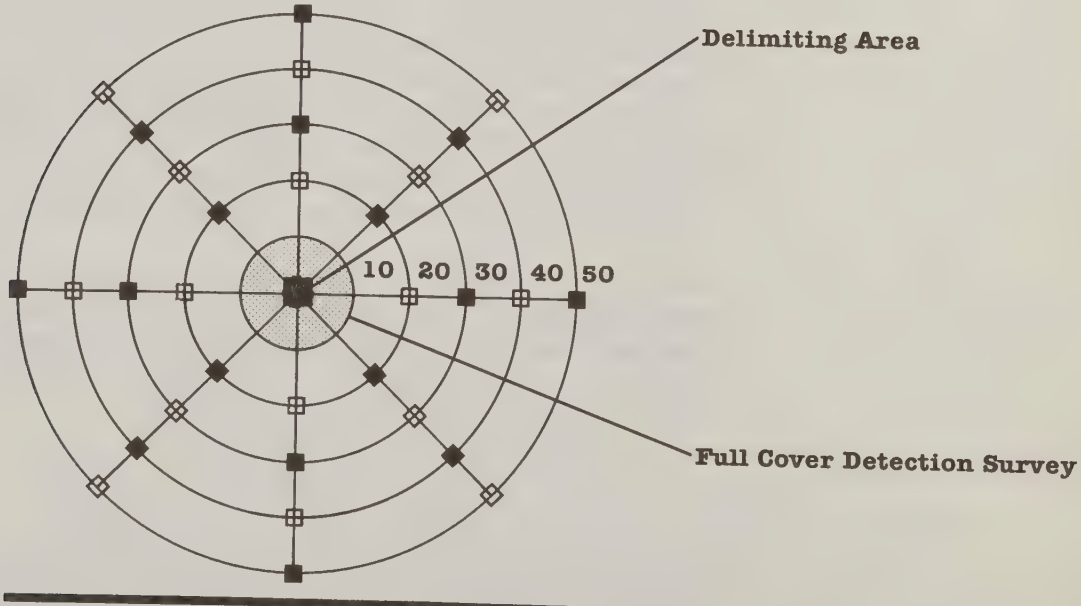
Sample areas with brownish patches where the grass has been eaten and looks obviously ragged. Sampling consists of taking a steel cylinder 8-in diameter by 8-in high and driving it into the soil (turf). The enclosed area is then treated with 1 gallon (gal) of 0.25 percent liquid detergent in water by volume. Liquid detergents known to be suitable are Joy, Ivory, and Wisk. The area must remain under continuous observation for 10 minutes, and any larvae which surface are collected live for identification or possible rearing.

4. Extended Detection Survey

Detection survey beyond the 10-mi buffer will be conducted in selected blocks at 10-mi intervals up to 50 mi from the core area. Each selected block will be on one of the eight points of the compass (N, NE, E, SE, S, SW, W, NW). There will be a bias in favor of the direction of air mass movement during periods when such movement is pronounced or may be a factor in Spodoptera spread, as determined by program personnel. Up to twice as many blocks may be concentrated in the applicable direction of air movement as in all other directions combined.

The trap and visual surveys in each block will be carried out as instructed in delimiting survey procedures.

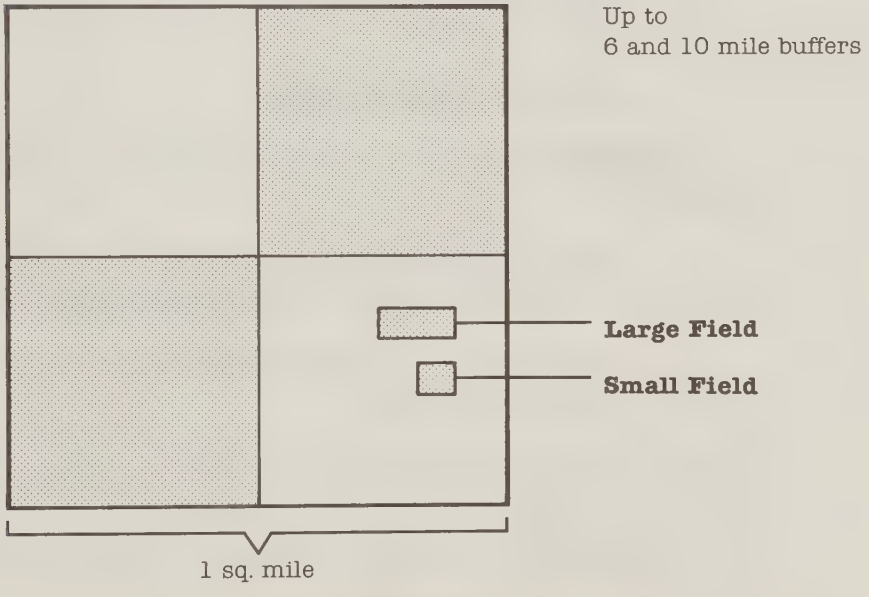
Detection Survey



Detection Survey Procedures:

--Locate suitable fields of host within each mi^2 block.
--For fields of 40 a or less use four traps.
--For fields of more than 40 a use one trap per 10 a.
--Traps are serviced and removed in 2 weeks.
--Suitable fields are defined as hosts with leaves, grass blades, etc.
--Maximum of 96 pheromone traps per block.
--32 detection blocks.
--Biweekly (pheromone) or daily blacklight trap collection.
--Visual survey in every other block (if possible).
--When pheromone traps can be used, blacklight traps are optional.

Block Trapping



A different selection of mi^2 blocks may be picked out for the following biweekly period with a bias for those with large areas of suitable host fields.

5. Backtracking

Long distance transport of migratory Spodoptera in moving air masses is of great concern. If adult Spodoptera are found without any other stages present, the find is not near a possible port of entry, found at a time of year when several generations could have elapsed, or in a northern location where it is obvious that they could not

have overwintered, then the possibility exists that the adults migrated to the site of the find(s).

Backtracking, in its simplest form, employs windfield maps. Trajectories are constructed using a sequence of windfield maps, starting from the estimated day and time of arrival (based on the circumstances found at the site and of likely air mass movements) and working back until a logical trajectory is constructed.

Site circumstances which provide clues to the estimated time of arrival include:

a. Finds associated with the arrival of a weather system.

b. The collection of adults without any indication of larval feeding.

c. Finds located in inland locations away from obvious ports of entry.

d. Sudden endings to finds.

e. Appearance of a new generation or stage in the life cycle.

f. Sudden outbreaks or increases in numbers not associated with estimated local breeding populations.

g. Reappearance of more finds in an area just cleared of the species involved.

Surveys are then carried out at logical places along the trajectory until the source (or sources) is found. Likely sources include areas near ports, southern areas where overwintering is possible, or where abundant hosts are available.

For the purpose of calculations, a moth air speed of one meter per second may be added to the movement of any given air mass.

Computer generated atmospheric trajectory analyses are available to help identify potential sources of infestation and to trace in time and space the probable movement of plant pests with air masses. One such program is the Branching Atmospheric Trajectory (BAT). This model (T.D. 9743 - BAT) is available from the National Climatic Center, Data Base Adminstration, Box 34, Federal Building, Ashville, North Carolina 28801.

6. National Survey

All other area, State, regional, and national survey programs will be asked to look for exotic Spodoptera in the course of regular survey work. This will be on a nationwide basis.

Addendum E--Life History

1. Systematic Position

Class: Insecta
Order: Lepidoptera
Family: Noctuidae
Genus: Spodoptera

There are approximately 25 species in this genus as it now stands. Some species have attained very extensive distributions, and others are widespread in Africa and South America, where most of the species seem to be concentrated. A number of species are of serious economic importance. The recognized economic species are as follows:

*Beet armyworm, Spodoptera exigua
Egyptian cottonworm, Spodoptera littoralis
*Fall armyworm, Spodoptera frugiperda
Lawn armyworm, Spodoptera mauritia
Nutgrass armyworm, Spodoptera exempta
Rice cutworm, Spodoptera litura
*Southern armyworm, Spodoptera eridania
*Western yellowstriped armyworm, Spodoptera praefica
*Yellowstriped armyworm, Spodoptera ornithogalli
*Endemic to continental United States

Of this number, five occur in the continental United States. Three species, S. exempta, S. litura, and S. mauritia, are established in Hawaii. Only S. littoralis is not established in any part of the United States.

2. Identification Characters

Some pre-identification and sorting can be done by field personnel assigned to the program.

The genus Spodoptera can generally be recognized by the medium size of the adults (wing span 24 to 43 mm), forewings varying from pale grayish brown to dark grayish brown with usually well-defined orbicular and reniform spots and whitish hindwings. Some additional microscopic characters include nonhairy eyes, no fringe of stiff hairs around the eyes (lashing) below the antennae, no spines on the prothoracic tibia, but possessing two rows of strong spines on last tarsal segment (of all legs). The veination of the wings is of the trifed type.

With experience, field and laboratory pre-identification may be possible in separating exotic Spodoptera from other species present in the local area. Charts useful for separating some species have been prepared. Spodoptera spp. such as S. abyssinia, for which no information is available, have been intentionally omitted from these charts. It is hoped that subsequent revisions will provide additional characters.

Character Comparison Chart—Spodoptera Egg Stage

Species	Hair-Scale Color	Laying Color	Hatching Color
littoralis	buff-gold brown	creamy white	blue/black pale below
litura	brown	pearly green	black
exempta	black	pale yellow	dull black
mauritia	buff-light brown	light tan	gray/dark tan
exigua	white	white/brown	brown
frugiperda	dirty white/gray	light gray	?
ornithogalli	black	?	?

Character Comparison Chart—Spodoptera Larval Stage

Species	Mandibular teeth	Mandible shape	Mandible dorsal margin	Feeding	Overwintering
littoralis	teeth distinct, serrate	oblong	straight	nighttime	?
litura	?	?	?	nighttime	?
exempta	teeth fused	square	straight	?	aestivation + diapause
mauritia	teeth fused	square	concave	?	?
exigua	teeth distinct, serrate	oblong	straight	?	?
ornithogalli	?	?	?	daytime	no true diapause
praefica	?	?	?	?	?

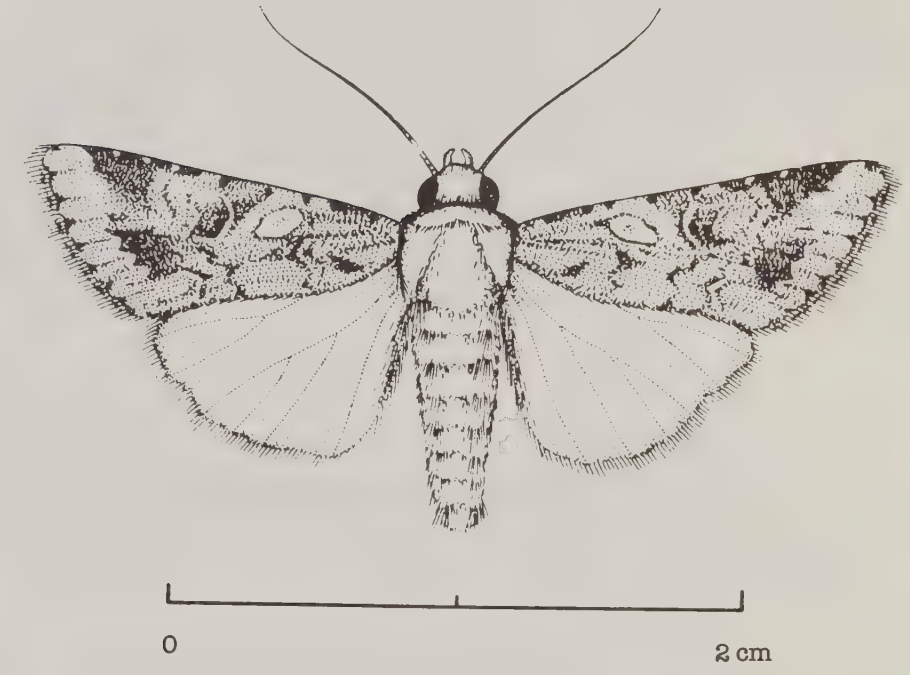
Character Comparison Chart—Spodoptera Pupal Stage

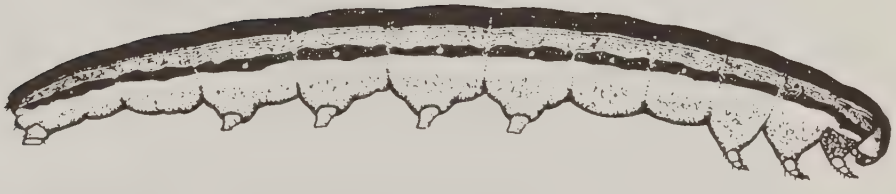
Species	Creamaster	Leg Rudiments Prothorax	Spines	Overwinters
littoralis	one pair of spines	extends behind metathorax legs	feebly divergent	?
litura	one pair of spines	?	?	?
exempta	one pair of spines	extends as far as metathorax legs	wide apart at base, parallel	?
mauritia	?	extends behind metathorax legs	narrow base, divergent	?
exigua	two pairs of spines	extends as far as metathorax legs	feebly divergent	?
frugiperda	one pair of spines	extends behind methatorax legs	wide base, divergent	?
ornithogalli	?	?	?	no true diapause
praefica	?	?	?	diapause
eridania	one pair of spines	extends behind metathorax legs	narrow base, parallel	?
sunia	one pair of spines	shorter and enclosed by metathorax legs	narrow, elongate base, parallel	?
ochrea	one pair of spines base with collar	extends behind metathorax legs	narrow base, divergent	?

Character Comparison Chart—Spodoptera Adult Stage

Species	Antenna Male	Male Outer Spur Middle Tibia	Male fore Tibia	Foretarsal Segment	Orbicular Spot	Reniform Spot
littoralis	filiform	less than ½ length inner spur	hair scales not tufted	wholly white (male)	open at distal end (male)	elongate to sharp point (male)
litura	filiform	?	?	?	?	?
exempta	filiform	less than ½ length inner spur	hair scales not tufted	black/white tips (male)	closed (male) closed/round (female)	square, scarcely produced
maurita	filiform	greater than ½ length inner spur	large mass hair scales	?	circular (male) round (female)	elongate apically to sharp point
exigua	filiform	?	?	?	circular (male) round (female)	pale, very small
frugiperda	filiform	?	?	?	oval, oblique dark, center	?
ornithogalli	filiform	?	?	?	?	?
pulchella	filiform	?	?	?	?	?
latifascia	filiform	?	?	?	?	?
dolichos	filiform	?	?	?	?	?
eridania	filiform	?	?	?	?	?
sunia	filiform	?	?	?	?	?
hipparis	pectinate	?	?	?	?	?

Spodoptera exempta





Spodoptera exempta

Spodoptera littoralis

Larva enlarged

Spodoptera littoralis

3. Biology

The following biology is based on Spodoptera littoralis, the Egyptian Cottonworm (ECW). Other species, in as much as they differ from ECW, will be mentioned subsequent to this description. As more information becomes available, pertinent items will be included in subsequent revisions of this document.

a. Spodoptera littoralis (ECW)

Adults mate immediately after emergence in warm weather, but in colder areas there is a preoviposition period of 2 to 11 days. A mated female may fly from twilight throughout the night. Eggs are laid in batches of 30 to 300. These eggs are usually covered with hairs shed from the female abdomen. The female may oviposit on any part of a plant, but the lower surface of leaves is preferred. On herbaceous plants, egg masses are generally found in the upper third of the plant. The female lays an average of 1,000 eggs, but is capable of laying as many as 3,700 eggs in her lifetime. Egg incubation lasts 2 to 26 days; 2 to 3 days in warm conditions, 3 to 6 days in cooler weather, and 10 to 26 days in cold weather. Natural egg mortality is very low, and a larva hatches from almost every egg. There are up to eight generations a year, with some overlapping of generations. In colder areas, there are only three to four generations which may pass per year.

The first two instars feed in small groups on the undersurfaces of leaves both day and night. These larvae usually cluster on the upper third of herbaceous hosts. Consequently, they are extremely sensitive to climatic conditions, especially combinations of high temperatures and low humidities. Temperatures above 104 ^{o}F (40 ^{o}C) or below 55 ^{o}F (13 ^{o}C) result in increased mortality.

After the third molt, the larvae scatter and lead solitary lives. The majority rest during the day in the upper soil layers and emerge in the evening to feed throughout the night.

Usually there are five or six larval instars. Larval development lasts 12 to 85 days; 12 to 18 days during hot summer months, and 70 to 85 days in the winter. Mortality levels are high in the larval stage, and most larvae do not complete development owing to the presence of numerous parasites and diseases. Unfavorable climatic conditions such as rain, falling temperatures, and short days also increase mortality and prolong the larval period.

Damage results from larval feeding on the leaves. With young larva on just infested hosts, damage begins as numerous small feeding points which spread over the entire leaf. The larger instars chew large holes or wholly consume the leaves, mine their way into young shoots or bare sections on young stalks, bolls, and buds. They may destroy fruit such as tomatoes and peppers. A heavy attack on young plants retards development, resulting in few or late fruit. Medicinal plants, where all leaf parts are important for essence, can suffer serious economic damage. Grapes may be left with only the leaf veins remaining; grape bunch stalks may be chewed, resulting in a dry bunch or the grape berries themselves are attacked. Finally, the vines may suffer so

severely that development the following year is retarded. In deciduous orchards, heavy damage to trees is caused by extensive leaf and terminal growing point feeding; young orchards suffer great damage. Ornamental plants and fruit trees in nurseries may suffer serious defoliation and die. If food in an area is short, then large numbers of larvae may migrate "en masse" to adjacent cropland. On some pasture land, leguminous hosts are preferred over gramineous hosts. If food is short, the digestive system retains and efficiently utilizes the food, but when food is abundant, it is inefficiently passed quickly so that large amounts of food far in excess of subsistence requirements are consumed. This in turn accounts for the extensive damage to crops in field situations.

Diapause is absent in ECW, and it overwinters best as late instar larvae. These develop slowly during the winter and pupate in the spring. Adults emerge over a brief period, partly because the overwintering population is of the same age and partly because development accelerates with increasing spring temperatures. In some areas, the pupae have appeared more tolerant to cold conditions than larvae.

The larvae pupate in cells 1 to 2 inches in the ground. The pupal period varies from 5 to 31 days; 5 to 10 days in summer, 14 to 19 days in spring/autumn, and 21 to 31 days in winter. Natural mortality of the pupae is high, especially in areas with a winter period. High soil temperatures at or above 78.8 ^{0} F also produce more than 50 percent mortality. Short days also increase mortality and prolong the pupal period.

The newly emerged moths are active from dusk to dawn. Females begin calling within 1 hour of dusk. They mate one or twice at most. Males may mate up to six times. Females live for 2 to 22 days; 2 to 7 days in summer, 3 to 11 days in spring/fall, and 10 to 22 days in winter. Male longevity is shorter than the female.

To some extent, longevity of the larval, pupal, and adult stages is dependent on the host plant; and the figures given above for these stages will vary considerably. In one experiment at 80.6 ^{0}F, the range of the average larval period on 56 selected hosts was 14 to 32.7 days; for pupae it was 6.1 to 11.3 days; for adults, survival varied between 3.8 to 13.4 days. The range of the sums of these figures is 28 to 50 days, depending on hosts. (This does not include the egg or oviposition periods.)

In summary, the life cycle or egg-to-egg period for ECW, from the figures just given, varies from a minimum of 19 days to 144 days.

It has never been proven that the ECW possesses migratory abilities. Local expansion from overwintering sites does occur at the rate of 2 to 5 mi each generation. Part of the explanation may lie in the fact that females first mate and lay at least one batch of eggs before wandering. Most eggs are laid on the first night. Males do emigrate many miles from the local area, sometimes in great numbers soon after sunset, if they cannot find females to mate with. If they mate, they will not emigrate on that night. Older females release pheromone at sundown; young ones (24 hours or less) a little later, so any males present will stay there if they mate. Females can attract males from as far as 98 yd downwind; but the general attractive radius is about 11 yd.

b. Spodoptera litura Rice cutworm (RCW)

The RCW has a lower temperature threshold than ECW (50 °F versus 55.4 °F). Females do not mate until the day following emergence, and eggs are laid 2 to 3 days after mating. The eggs are deposited at night in batches of up to 300 on the undersurface of host leaves. Egg batches may also be laid on other flat surfaces such as the walls of houses. Over a lifespan of up to 7 days, a female may deposit six to nine egg batches. Eggs hatch in 4 days at an optimum temperature of 80 °F. Newly hatched larvae are very susceptible to dry heat, hence they usually stay on lower leaf surfaces during the day and feed at night. In the last two instars, they feed only at night and seek shelter during the day under the lowest leaves or in the soil at the base of the host. The larvae pass through six instars. At an optimum temperature of 83.5 °F, the larval stage lasts 13 days. Damage is caused by defoliation of the host or by chewing the host like a cutworm.

Pupation is within earthen cells in the soil. At a soil temperature of 83.5 °F, this takes 7.3 days for males and 6.1 days for females.

Adults emerge at night between 11 p.m. and 3 a.m. Males will fly up to 3.1 mi per night, but flights are greatly reduced at temperatures below 68 °F. Males mate once each night and avoid previously mated females.

c. Spodoptera exempta Nutgrass Armyworm (NAW)

The NAW usually migrates immediately after emergence. Mating and oviposition may be delayed until the moths (male and female) have traveled tens or hundreds of miles, generally downwind. This results in dense population concentrations in limited areas where winds converge. This behavior pattern would appear to be a major difference between NAW and other exotic Spodoptera. Other migratory Spodoptera are already in North America: ie., S. exigua, S. frugiperda, S. dolichos, and S. eridania.

Addendum F--Identification of Specimens

As many specimens as possible of the pest are to be collected for identification by the local designated identifier. Suspect adult specimens should be forwarded dry in a small cardboard box and other stages in vials of alcohol for confirmation. (See below.) These specimens must be accompanied by PPQ Form 391 (Specimens for Determination) marked "Urgent" (see PPQ General Operational Procedures Manual M390.500).

INFORMATION FLOW FOR THE IDENTIFICATION OF SPECIMENS

SPECIMENS COLLECTED
¶
V
SCREENING/IDENTIFICATION BY STATE OR PPQ
¶
V
SPECIMENS SUBMITTED TO USDA[1/]
for Confirmation
¶
V
CONFIRMATION NOTIFICATION[2/]
to Other USDA Agencies
¶
V
RESULTS SENT TO APHIS AND IF EXOTIC
Information Relayed to [2/] [3/]

1/	ARS	Biosystematics and Beneficial Insects Research Institute Agricultural Research Service U.S. Department of Agriculture Building 476, BARC-EAST Beltsville, Maryland 20705
	APHIS	Plant Protection and Quarantine
2/	All States	State and Territory Agricultural Regulatory Officials
3/	NAPPO	North American Plant Protection Organization

Addendum G--Forms

To be added later.

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Addendum I--References

The literature on Spodotera is very extensive. Only a few of the most pertinent publications are listed.

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